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DOI:
10.1051/sm/2018004

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (Harvard):
Lepers, R, Li, FX & Stapley, PJ 2018, 'Swimrun: an emerging new endurance sport', *Movement and Sports Sciences - Science et Motricite*, vol. 100, no. 2, pp. 53-58. https://doi.org/10.1051/sm/2018004

Movement & Sport Sciences - Science & Motricité 2018, **100**, 53–58
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https://doi.org/10.1051/sm/2018004

Movement & Sport Sciences
Science & Motricité

Available online at:
www.mov-sport-sciences.org

ARTICLE

Swimrun: An emerging new endurance sport

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Received 21 June 2017, Accepted 10 February 2018

Abstract – The swimrun is a new endurance team-sport based on two persons swimming and running alternatively through open water and mostly trails. The aim of this study was to analyse participation and performance trends for males, females and mixed duo team at the ÖTILLÖ Swimrun race (10 km open-water swimming and 65 km trail running). During the 2012–2016 period, the mean total time performance of the best athletes at the ÖTILLÖ Swimrun decreased significantly by 17 min/year for males, 40 min/year for mixed and 59 min/year for females duo, respectively. The difference in performance between the best males and females duo (26 ± 15%) was significantly greater compared to the difference between males and mixed duo (12 ± 8%). The number of swimrun races organized across the world has dramatically increased these last years and will probably continue to grow up in the future. Swimrun athletes are still not very experienced, thus both improvements in performance and reduction in sex difference are expected in the next decade.

Keywords: swimming, open-water swimming, trail running, sex difference, ultra-endurance

Résumé – Swimrun : l'émergence d'un nouveau sport d'endurance. Le swimrun est une nouvelle épreuve d'endurance par équipe de deux personnes qui alternativement nagent en eaux libres et courent la plupart du temps sur des sentiers. Le but de cette étude est d'analyser l'évolution de la participation et des performances pour les équipes hommes, femmes et mixte sur l'épreuve ÖTILLÖ Swimrun (10 km natation en eau libre et 65 km de course à pied). Au cours de la période 2012–2016, la performance chronométrique moyenne des meilleurs athlètes à l'ÖTILLÖ Swimrun s'est améliorée respectivement de 17 min/an pour les équipes hommes, 40 min/an pour les équipes mixtes et 59 min/an pour les équipes femmes. La différence de performance entre les meilleures équipes masculines et féminines (26 ± 15 %) est significativement plus grande par rapport à la différence entre les équipes masculines et mixtes (12 ± 8 %). Le nombre d'épreuves swimrun organisées à travers le monde a considérablement augmenté ces dernières années et va probablement continuer d'augmenter à l'avenir. Les performances des meilleurs athlètes devraient continuer de s'améliorer au cours de la prochaine décennie avec notamment une réduction de la différence de performance entre les sexes.

Mots clés : natation en eau libre, course trail, différence entre les sexes, ultra-endurance

1 Introduction

Endurance disciplines such as trail running or triathlon emerged during the 1980's and have grown progressively to reach a very high level of popularity. After an initial phase of rapid improvement of performances, there has been a relative plateau, with small improvements for both males and females and relative stability in performance differences between the sexes (*e.g.* Hoffman, & Wegelin, 2009; Hoffman, Ong, & Wang, 2010; Knechtle, Knechtle, & Lepers 2011; Lepers, 2008; Lepers, Rüst, Stapley, & Knechtle, 2013). Recently, a new endurance sport called 'swimrun' has emerged. Swimrun is a two persons team-sport involving non-stop multiple segments of swimming and running. The swim legs are undertaken in open-water (lakes or the ocean) and run legs take place usually cross-country on various surfaces, mostly trails. The team mates can help each other, including pulling the weakest member using a tether. A major rule of the event is that competitors must carry their equipment with them for

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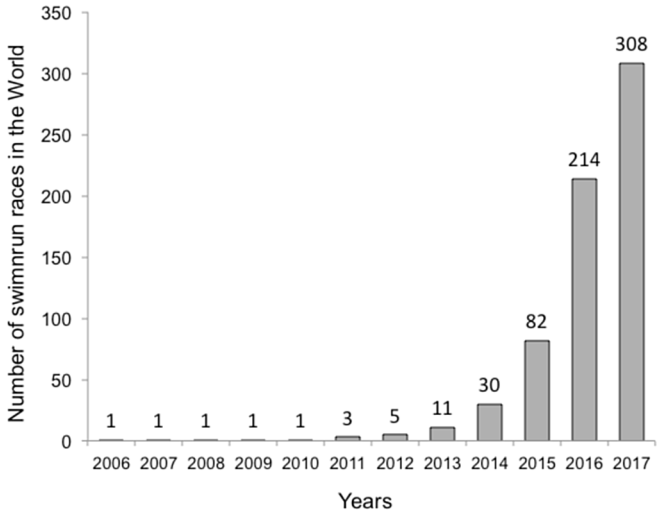

Fig. 1. Number of swimrun races in the world from 2006 to 2017 (adapted from http://www.worldofswimrun.com).

the length of the race. This means that generally, the athletes swim with their running shoes on and run whilst wearing their wetsuit. The first official event called ÖTILLÖ (Swedish for "Island to island") Swimrun took place in Sweden in 2006 (http://otilloswimrun.com), and remained rather confidential until 2011 and is now self-labelled 'World Championship'. The total distance of ÖTILLÖ Swimrun is 75 km of which 10 km is open-water swimming and 65 km of trail running over 24 islands of the Stockholm Archipelago. Competitors can qualify or accumulate points in a series of shorter events. The best male duo teams finish the ÖTILLÖ Swimrun in around 8 hours making it an ultra-endurance performance.

According to the international swimrun website (http://www.worldofswimrun.com/), the number of swimrun races has increased exponentially since the first official event held in Sweden in 2006 (see Fig. 1). In 2016, 214 swimrun races of different distances took places in the world compared to only 11 races in 2013. The number of confirmed swimrun races for 2017 has already reached 308 and every month more races are announced. Races are organized all around the world in more than 20 countries, but most races still take place in Sweden with 89 races scheduled for 2017. France is the second largest swimrun country in the world with 50 races followed by the UK ($n = 21$) and Italy ($n = 20$).

In swimrun races, athletes can compete in male, female or mixed duo team categories. A duo team category can influence race strategy as the two teammates have differing physiological characteristics and levels of performance in both swimming and running. Strengths and weaknesses of each teammate may therefore influence the pacing strategy and team performance. Sex differences in endurance performance have been extensively examined in literature (*e.g.* Joyner, 2017; Lepers, Rüst, *et al.*, 2013; Lepers, Knechtle, *et al.*, 2013; Senefeld, Smith, & Hunter, 2016; Senefeld, Joyner, Stevens, & Hunter, 2016). Differences in endurance performance between the best males and females vary between 10% and 14% depending on the discipline with the smallest difference observed for open-water races (Eichenberger *et al.*, 2012, 2013). Swimrun represents an interesting model to compare endurance performance between male and female duo teams, and mixed duo teams. In particular, the influence of the partner's gender on a female athlete's performance can be examined.

The aims of this paper were therefore twofold:
- to analyse performance trends for male, female and mixed duo teams at the ÖTILLÖ Swimrun (the premier swimrun event in the world);
- to analyse participation trends and compare performances of male, female and mixed duo teams at five races of the ÖTILLÖ Swimrun qualifying series.

We hypothesized:
- the performances of the best swimrunners had improved at ÖTILLÖ Swimrun during the last years;
- the level of performance of the mixed duo would be intermediary between those of the males duo and the females duo.

2 Methods

Approval for the project was obtained from the Burgundy University Committee on Human Research. The dataset from this study was obtained from the ÖTILLÖ Swimrun website: http://otilloswimrun.com

2.1 ÖTILLÖ Swimrun

Since 2012, the ÖTILLÖ Swimrun is held each year on the first Monday of September in the Stockholm Archipelago, Sweden with only minor changes in the course. This race is now internationally recognized as the World Championship of the discipline though it is not part of a federation. The ÖTILLÖ Swimrun is point-to-point race, combining a 10 km open-water swim in the Baltic Sea and a 65 km trail run with more than 50 segments that cross around 26 islands. The temperature of the water is around 13 °C and the temperature of the air is around 15 °C. The swim part can be rough due to possible current and waves. The run course takes place on trails and road and can be slippery at the entrances and exits of the water. Aids stations are provided to the athletes at several occasions during the event. The athletes generally performed the whole race with a special wetsuit with short legs and short or long sleeves. They could additionally used hand-paddles, pull-boy and a tether or an elastic cord between the teammates. As only complete results (total times for each duo team) are available for the ÖTILLÖ Swimrun since 2012, we analysed only the 2012–2016 period in this study. The times of each swim and run segment are also not available so only total times were analysed. Total time performances of the top 3 male, female and mixed duo teams were analysed. The average of the top 3 performances provided a more accurate detection of performance change than winning time alone.

2.2 ÖTILLÖ Swimrun series

In order to obtain a deeper insight into the participation and performance trends of this new endurance sport, we analysed the main five races of ÖTILLÖ Swimrun series held for the first time in 2016. These races were chosen because they are considered as very competitive in the swimrun field and served as qualifying races for the ÖTILLÖ Swimrun World Championship. These four races included:
– the 'Engadin' swimrun in Switzerland (6 km swim, 47 km run);
– the '1000 lakes' swimrun in Germany (10 km swim, 33 km run);
– the 'Isles of Scilly' swimrun in UK (7.5 km swim, 30 km run);
– the 'Utö' swimrun in Sweden (4.5 km swim, 35 km run).

We also considered the ÖTILLÖ Swimrun World Championship in Sweden (10 km swim, 65 km run) within this analysis. The total number of team duo starters and finishers were considered for these five events. The total time performances of the top 5 male, female and mixed duo teams were analysed and considered for comparison of the magnitude of the performance differences:
– between male and female duo teams and;
– between male and mixed duo teams.

The performance density (*i.e.* the time difference between the winner and the fifth placed duo) was also analysed and expressed as a percentage of the winning performance for male, female and mixed duo teams, respectively.

2.3 Statistical analysis

Data are reported as mean ± SD within the text, the table and the figures. Linear regressions were used to estimate the changes in performance per year for ÖTILLÖ Swimrun race. Pearson's correlation coefficients were used to assess the association between the variables. One-way ANOVA was used to compare the differences between male and female duo, and males and mixed duo team performances. A significance level of $P < 0.05$ was used to identify any statistical significance.

3 Results

Trends in finish times of the top 3 males, females and mixed duo team at the ÖTILLÖ Swimrun are shown in Figure 2. Since 2012, the performances at the ÖTILLÖ Swimrun improved for the three categories but at a faster rate for female teams. During the 5-year period, the mean total time performance decreased significantly by 17 min/year for male teams, 40 min/year for mixed teams and 59 min/year for female duo teams, respectively. Interestingly, in the last three years, among the athletes finishing in the top 3 duo team, 90% were Swedish (81% for males duo team, 99% for females duo team and 93% for mixed duo team respectively). The other 10% were composed of athletes from Canada, France, Australia, Finland and Switzerland.

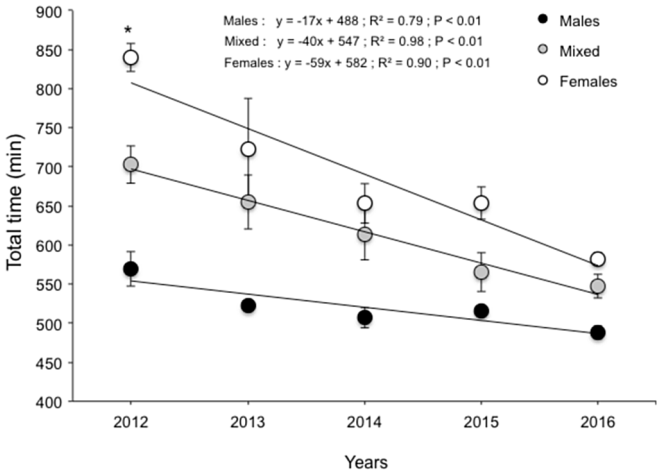

Fig. 2. Total performance times at the ÖTILLÖ Swimrun for the top 3 male, mixed and female duo teams from 2012 to 2016. Values are means ± SD. * only two female duo teams finished this race. Regression lines are presented from 2012 to 2016. The equations are for the year 2016 as 0, so the intercept is the time in the year 2016. The slope of each equation indicates the change in time (min) performance per year since 2012.

Table 1 shows the participation at the five races of ÖTILLÖ Swimrun series in 2016. The number of duo team starters ranged from 81 to 244 across the races. The percentage of teams that did not finish within the time delay or withdrew (DNF) during the race ranged from 4 to 33%, the lowest rate occurring during the ÖTILLÖ Swimrun World Championship. Male, mixed and females teams represented on average 66 ± 3%, 23 ± 4% and 11 ± 5% of the finishers, respectively.

The mean total time performances of the top 5 finishing teams at the ÖTILLÖ Swimrun series are presented in Figure 3A. Total times varied between 244 min and 459 min for the top 5 male duo teams, between 261 min to 558 min for the top 5 mixed duo teams and between 290 min to 603 min for the top 5 female duo teams. In 2016, the average difference in time between the winners and 5th place-finishers at the ÖTILLÖ Swimrun series was equal to 5 ± 1% for male teams, 17 ± 6% for mixed teams and 23 ± 21% for female duo teams, respectively.

The difference in performance between male and female duo, and between male and mixed duo teams are presented in Figure 3B. The difference in performance ranged from 17% to 44% between male and female duo teams, and from 5% to 25% between male and mixed duo teams, respectively. On average, the difference in performance between male and female duo teams was significantly greater compared to the difference between male and mixed duo teams (26 ± 15% *vs.* 12 ± 8%, $P < 0.01$).

4 Discussion

The present study is the first to describe participation and performance trends in swimrun. Even if this discipline

Table 1. Numbers of starters, DNF (did not finish in the time delay or withdrawn) and total finishers, for male, mixed and female duo team finishers at the five main races of the ÖTILLÖ Swimrun series in 2016.

Races	Starters	DNF	Finishers	Males		Mixed		Females	
Ötillö (SWE)	115	5	110	67	61%	27	25%	16	15%
Engadin (SUI)	160	37	123	84	68%	30	24%	9	7%
1000 Lakes (GER)	150	49	101	68	67%	28	28%	5	5%
Isles of Scilly (GBR)	81	11	70	47	67%	12	17%	11	16%
Utö (SWE)	244	13	231	157	68%	51	22%	23	10%
Mean	**150**	**23**	**127**	**85**	**66%**	**30**	**23%**	**13**	**11%**
SD	**61**	**19**	**61**	**43**	**3%**	**14**	**4%**	**7**	**5%**

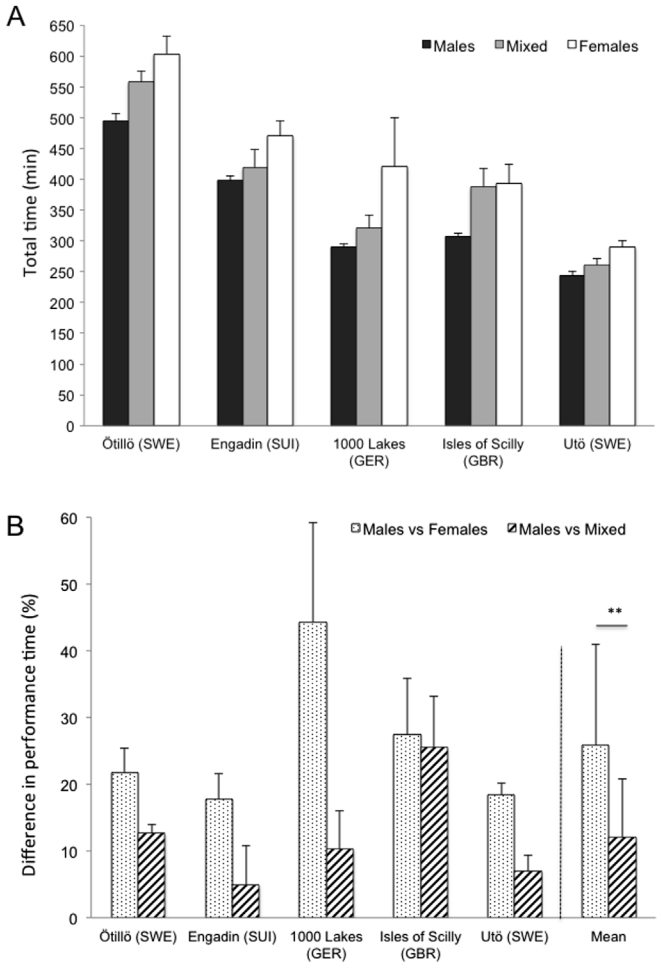

Fig. 3. Total performance times at the five main races of the ÖTILLÖ Swimrun series for the top 5 male, mixed and female duo team in 2016. Values are means ± SD (Panel A). Mean difference in performance time between the top 5 male *vs.* female duo teams and the top 5 male *vs.* mixed duo teams at the five main races of the ÖTILLÖ Swimrun series. The histograms on the right side represent the mean value of the five races. Values are means ± SD (Panel B).

remains novel in (ultra)-endurance sports, the exponential increase in swimrun races in the world over the past few years suggests that the development of swimrun will continue in the future.

Performances at the de facto World Championship ÖTILLÖ Swimrun and therefore the premier race of the field have improved significantly over the past five years. This improvement was in relation to absolute performance times. Indeed, female duo teams, who were the slowest, showed the greatest performance improvement with on average 59 min per year during the 2012–2016 period. Greatest performance improvement for females compared to males has already been observed in other ultra-endurance events such as triathlon (*e.g.* Lepers, 2008; Knechtle *et al.*, 2016) and can be explained by increase in women's participation in endurance events and better preparation for an event (increase volume and intensity of training). However, the greatest performance improvement of female duo these last years evidenced by the linear regression must not be misinterpreted. It is obvious that female duo performance will soon plateau and female duo will not beat male in the future.

Improvements of the female duo teams were followed by the mixed duo teams and the males, who only improved, on average, by 17 min per year. The different rates of improvement across the years between males and females have been previously observed for endurance disciplines (*e.g.* Lepers, 2008). Because swimrun is a new endurance sport, we could expect further improvements before a plateau in performance is achieved due in particular to improvements in training techniques and specific equipment such as wetsuit and running shoes adapted to both swimming and running. Specific training methods are not commonly used yet and people tend to simply add swimming and running training, plus some transition practice. More experimentation and research is needed to define the specifics needs of swimrunning training. Similarly equipment has mostly been 'borrowed' from running and swimming and this is mildly satisfactory. The biggest improvement has occurred in wetsuits, but other items will follow suit, probably leading to further time improvement.

The last years, Swedish swimrunners have dominated the World Championship ÖTILLÖ Swimrun. This domination could be explained by the Swedish origin of this sport and thus inducing a greater number and density of Swedish swimrunners and also more years of specific training/preparation. Swedish swimrunners who can train all the year on the course of the race have a significant advantage. This also highlights the specificity of the

preparation of swimrun race in taking into account of temperature of water and air, the nature of the trial and water environment.

Mean participation rates in swimrun events such as the ÖTILLÖ swimrun series remain limited with an average of 150 teams *i.e.* 300 participants per event. Generally, the race organisers limit the number of participants for safety and environmental reasons. Indeed, the several open-water swimming segments of swimrun events require a larger number of safety devices than in single-swim event such as triathlon. Interestingly, the percentage of withdrawals (Did Not Fish, *i.e.* DNF) varied greatly between the races. The lowest percentage of DNFs (4%) was observed for the ÖTLLÖ Swimrun World Championship. This result could be explained by a higher level of participants at this race compared to other races in the series. Indeed, most participants at the ÖTLLÖ Swimrun World Championship had to either earn a qualifying slot on previous event of the ÖTILLÖ swimrun series or are selected by the organisation according to their previous results in endurance events, and only a few gain a place *via* a lottery. The great percentage of withdraws (33%) was observed at the "1000 lakes" swimrun races taking place in October 2016 in Germany and could be explained by the cold weather conditions. Indeed, during all swim segments water temperature was hovering around 10 °C while the ambient temperature varied during the day from 5 to 10 °C. It has been reported that the best females were swimming faster in cold water than the best males in an open-water ultradistance swim (Knechtle, Rosemann, Lepers & Rüst, 2014). The possible advantage for females in swimrun events, where water temperature are frequently lower than 15 °C, needs to be explored. Even if swimrunners wear a wetsuit in nearly all the swimrun races, thermoregulatory and physiological responses to such exercise performed in extreme environment for long duration remain to be explored by physiologists (Tipton, & Bradford, 2014). In particular, the alternance of cold water and warmer air temperature leads to substantial multiple thermic shocks.

The female teams represented on average 11% of the total teams of ÖTILLÖ Swimrun series but the percentage of female participation varied greatly (from 5% to 16%) among the five races of the series. If we also consider female participation in the mixed team, females represented ≈23% of the total field of participants that are similarly distributed between female duo and mixed duo teams. Female participation in swimrun appears similar to that observed for other endurance disciplines such as triathlon (Lepers, Knechtle, *et al.*, 2013) or trail running (Hoffman, *et al.*, 2010) but remains lower compared to female participation in road running marathon (Lepers, & Cattagni, 2012). In addition to the gender distribution among the participants, it would also be interesting to know the age distribution of the swimrunners; unfortunately the age data was not provided. Previous studies have shown that for endurance disciplines, master athletes (*i.e.* older than 40 years old) currently make up some 50% of the total field of finishers (Lepers, Rüst, *et al.*, 2013). Moreover, the age of the best elite ultra-endurance athletes such as triathletes has been shown to increase over the last decade while their performances improved (Lepers, Rüst, *et al.*, 2013). We therefore can assume that master athletes also represent a high percentage of the swimrun participants but this assumption will need to be verified through additional analysis.

The results showed the mean time between the winners and the 5th place-finishers was much lower for the male duo compared to mixed and female duo teams. Greater performance density in males compared to females has been observed for international endurance races such as triathlon and trail running (Lepers, 2008; Hoffman, & Wegelin, 2009). Improvements in performance density, in particular for female and mixed duo teams, are expected for swimrun races in the future.

Analysis of swimrun races performances of the ÖTILLÖ Swimrun series showed that sex difference in performances between males and females team was greater than that previously observed for ultra-endurance disciplines such as triathlon (Lepers, Rüst, *et al.*, 2013), which is generally close to 12%. Because swimrun is relatively new in the field of ultra-endurance, females may have as much experience than males but we may expect that the sex difference in swimrun performance will narrow in the future.

The results showed that the performances of mixed duo were better than those of female duo teams. Even if we cannot exclude that the best females prefer to compete in the mixed duo category than in females category, a more plausible explanation comes from a specific rule of swimrun races that allows the use of a tether or an elastic cord between the teammates. This tether can therefore help the weakest athlete of the duo in swimming by providing him or her guidance and traction, but it could also help during the running segment. We might argue that in the best mixed duo teams, the males provide support to the females by using the tether and therefore they perform better than if they were in a female duo team.

4.1 Limitations, practical applications and implications for future research

Swimrun performance is greatly influenced by environmental conditions such as current, waves and water temperature but also the type running course (trail, road or rocks), therefore the present findings cannot be generalized to all swimrun events. A limitation is that specific anthropometric (*e.g.* percent of body fat) and physiological characteristics (*e.g.* maximal aerobic capacity) were not determined in the best swimrun athletes but are also missing in scientific literature. Future studies need to examine these specific variables in order to compare, for example, with long-distance triathletes. Additionally, the aspect of previous experience and sporting background has not been included in the present study.

The findings of the present study might be useful for both researchers and coaches working with swimrun athletes. Since there is no previous information about swimrun races in literature, these findings can be used in future studies as a reference. The knowledge about performance characteristics in such races might help coaches to prepare optimally their swimrun athletes before a race in extreme conditions, especially considering sex differences and racing in duo teams (males, females or mixed).

The specificity of racing in duo teams also offers the possibility of studying psychological aspects between the teammates and the team strategy to optimise performance. In addition, because the athletes need to bring all their equipment from start to finish, technological improvements (*e.g.* specific wetsuit and running shoes designed for both swimming and running) are still required to maximally optimize performances. Swimrun is an emergent (ultra)-endurance sport and research into this sport is sparse. Further investigations are required to better understand the psychological (*e.g.* duo team race strategies), biomechanical (swimming with running shoes) and physiological (*e.g.* swimming in cold water after running) aspects of swimrun.

5 Conclusion

Swimrun is a new endurance sport and the increase in the number of swimrun races organized across world will probably continue in the future. Swimrun athletes are still not very experienced, thus both improvements in performance and reduction in sex difference are expected in the next decade. The combination of open-water swimming and trail running, where athletes need sometimes to deal with cold water and steep and difficult trail running, will provide new opportunities to study human physiology in extreme conditions.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to this article.

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Cite this article as: Lepers R, Li F-X, Paul, & Stapley J (2018) Swimrun: An emerging new endurance sport. Mov Sport Sci/Sci Mot, **100**, 53–58